Important Anatomical Relationships of the Posterior Interosseous Nerve in the Distal Forearm for Surgical Planning: A Cadaveric Study

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Abstract

A thorough knowledge of the anatomy of the terminal branch of the posterior interosseous nerve (PIN) and its relationship to the anterior interosseous nerve (AIN) is essential in facilitating regional anesthetic blocks and planning surgical exposures for wrist surgery and arthrodesis of wrist and proximal row carpectomy. This cadaveric study focused on the anatomy and course of the PIN and its anatomical relationships at the distal forearm. Thirty embalmed cadaver forearms were dissected using microsurgical techniques. A structured pro forma was used to collect data. The PIN was consistently found in the fourth extensor compartment in all specimens. The last motor branch was given off 46.9 ± 8.4 mm (mean ± standard deviation) from the most proximal part of the ulnar head. The AIN was found lying consistently on the anterior aspect of the interosseous membrane, being on average 2.8 ± 0.2 mm (mean ± standard deviation) from the PIN. This knowledge will facilitate the planning of diagnostic and therapeutic procedures associated with the wrist.

Keywords
- cadaveric wirst study
- terminal posterior interosseous nerve
- denervation wrist surgery

A thorough knowledge of the anatomy of the terminal branch of the posterior interosseous nerve (PIN) and its relationship to the anterior interosseous nerve (AIN) is essential in facilitating regional anesthetic blocks as well as in planning surgical exposures for wrist surgery. Division of the PIN has been recommended in patients with persistent wrist pain who have not responded to conservative treatment and whose physical demands are low.[1] Denervation of the PIN is undertaken as an adjunct to salvage procedures for arthritis of the wrist, such as four-corner fusion and proximal row carpectomy. In addition, the last motor branch of the PIN has been a source of nerve grafts.

The wrist joint capsule is supplied by the terminal branches of the AIN, PIN, lateral cutaneous nerve of the forearm, median nerve, and dorsal branch of the ulnar nerve. Total wrist denervation may provide pain relief, but multiple incisions and the possible loss of proprioception are potential problems.[2–5] Partial denervation of the terminal branches of the AIN and PIN can be achieved with a single incision on the dorsum of the wrist.[2]

The current study focuses on the terminal branches of the PIN, particularly in the forearm, and analyzes the consistency of its anatomic location, its dimensions, its last motor branch, and its relationship to the most proximal part of ulnar head and the AIN, as these parameters may have clinical relevance for diagnostic and therapeutic procedures in and around the wrist.

Methods

Thirty embalmed forearms, 15 right and 15 left, 18 males and 12 females, with a mean age of 81 (range 37 to 96 years) were dissected. Demographic data were obtained from the records maintained in the anatomy department. These selected

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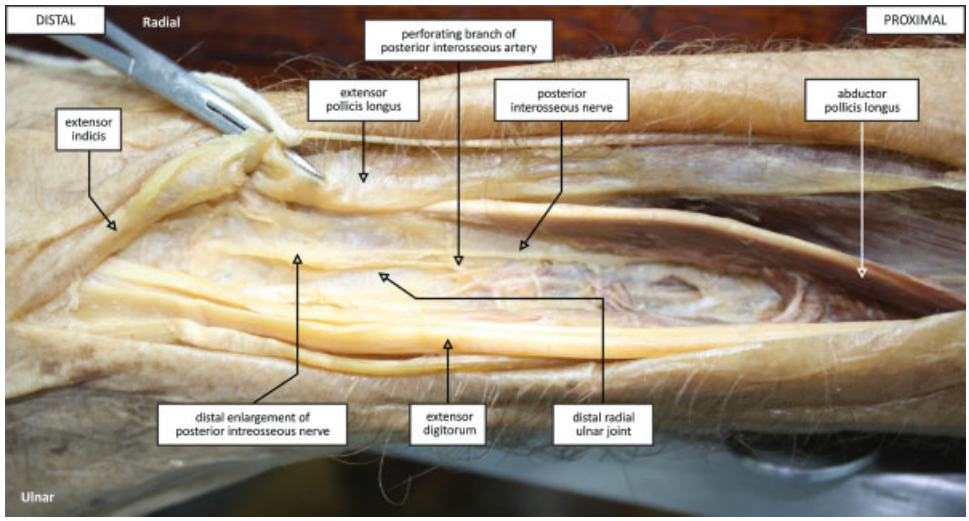

Fig. 1 The anatomy of the terminal branch of the left PIN in the distal forearm.

cadaveric forearms were without a history of surgery to the dorsum of wrist. There were no other exclusion or inclusion criteria. Microsurgical techniques using a 3× loupe magnification and fine hand instruments were used to carry out the dissections.

A structured pro forma was used to collect data specifically with respect to the location of the terminal branches of the PIN on the dorsum of the wrist, its size, and its relationship to the posterior interosseous artery and AIN. The last motor branch of the PIN was noted, and its distance from the most proximal part of the ulnar head measured using a digital caliper (Electronic Digital Vernier Caliper E010, Hangzhou Jianyu Industrial Co., Hong Kong, China).

Thompson's posterior approach to the dorsum of forearm and wrist was performed.[6,7] The forearm was placed in pronation with the palm against the table top. A skin incision was made along a line from the tip of the lateral epicondyle of the humerus to a point corresponding to the middle of the posterior aspect of the wrist. The extensor digitorum and extensor carpi radialis brevis were separated, upon which the PIN was observed emerging from underneath the deep head of the supinator. Once identified proximally, the PIN was followed distally as far as the extensor retinaculum. The dorsal tubercle of the radius (Lister's tubercle) was located, and the fourth extensor compartment on the dorsum of the wrist (containing the extensor digitorum and extensor indicis tendons) was opened longitudinally. The extensor digitorum and extensor indicis were mobilized medially, and the PIN was located together with the accompanying posterior interosseous artery on the radial aspect of the fourth extensor compartment. The nerve was particularly easy to isolate, as the cross-sectional area increased two- to threefold just proximal to the dorsal wrist capusle (►**Fig. 1**).

A capsulotomy of the distal radioulnar joint (DRUJ) was undertaken and the DRUJ exposed. Thereafter the most proximal part of the ulnar head was identified and confirmed by gentle prodding with a sharp pointer to demarcate it. Using a digital caliper, the diameter of the PIN was measured at the most proximal part of the ulnar head. The distance from this same point to its last motor branch proximally was also measured using the caliper (►**Fig. 2**).

The interosseous membrane was then opened longitudinally. The anterior interosseous neurovascular bundle was found lying immediately volar to the membrane. The sagittal (anterior–posterior) distance between the PIN to the AIN was measured using the digital caliper at the level of the most proximal part of the ulnar head.

Results

The PIN was consistently identified in all 30 embalmed cadaveric forearms. After emerging from the lower border of the supinator, the PIN was observed to divide into two branches after supplying the extensor pollicis longus. The medial branch was found to terminate in the extensor indicis; the lateral branch was seen to continue distally, lying on the interosseous membrane deep to the extensor pollicis longus. The PIN was observed to lie lateral (radial) to the extensor digitorum and extensor indicis in all forearms studied. After giving off its last motor branch, the PIN was observed to continue distally as a single sensory branch terminating in the fourth extensor compartment in all specimens.

The mean diameter of the PIN at the proximal part of the ulnar head was 0.5 mm (range 0.4–0.7) (►**Table 1**). The PIN was observed to decrease in diameter as it passed distally over the interosseous membrane; however, it increased in diameter while traversing through the fourth extensor compartment (►**Fig. 2**) in 11 of the 30 specimens. The last motor branch of the PIN supplied the extensor indicis (21 forearms, 70%) or extensor pollicis longus (9 forearms, 30%). The mean distance of the last motor branch to the most proximal part of the ulnar head was 46.9 mm (►**Fig. 2** and ►**Table 1**).

In all specimens the anterior interosseous artery was found immediately volar to the interosseous membrane, with the AIN ulnar to it in all specimens. The mean

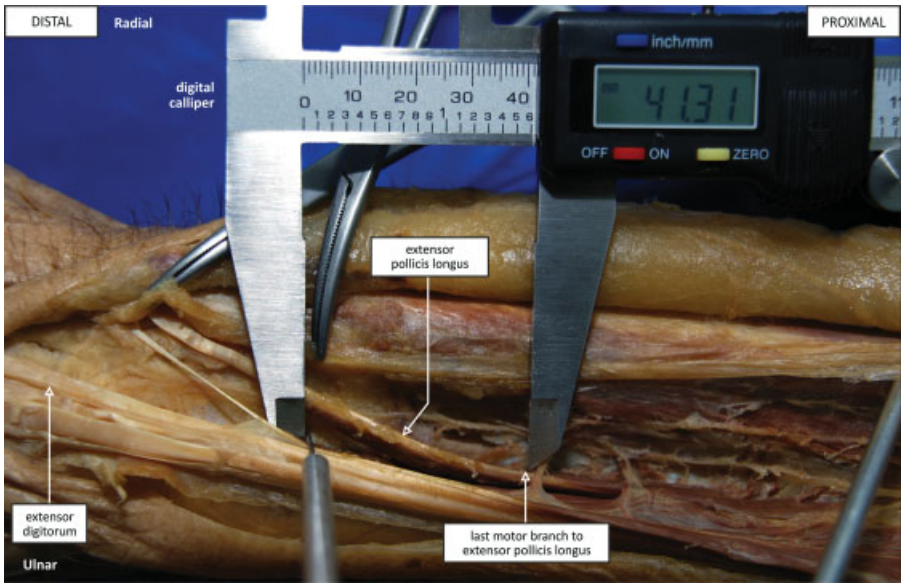

Fig. 2 Measuring the distance between the last motor branch of the PIN and the proximal part of the left DRUJ.

anteroposterior distance between the PIN and the AIN was 2.8 mm at the most proximal part of the ulnar head (►**Table 1**).

Discussion

The key findings of this study are the consistency of the PIN in the fourth extensor compartment, its close relationship with the AIN, the constant association of the AIN and the anterior interosseous artery, and, most importantly, the relationship between the PIN and the most proximal part of the ulnar head.

The present study proposes that the most proximal part of the ulnar head can be used as an anatomical landmark for procedures and denervation surgery at the wrist. Anatomical landmarks, such as the lateral epicondyle of the humerus or the lateral border of the supinator,[8] have been used to define a reference point for the PIN. However, for hand surgeons the lateral epicondyle, or any proximal forearm landmark, is less desirable, as it is usually outside the surgical field. The most proximal part of the ulnar head is a more suitable landmark for distal wrist surgery, as it is easily located and is within the field of surgery. Anatomical approaches for the majority of dorsal wrist surgical procedures requires working around the DRUJ and hence, in turn, the ulnar head; therefore, isolating it is straightforward, as it can be palpated. In addition, in cases where percutaneous or minimal invasive procedures are undertaken, the DRUJ can be identified with radiographs in the theater.

The present study shows that the most proximal part of ulnar head has a close and consistent relationship with the PIN and its last motor branch. This is important practically, as it provides a safe zone from the ulnar head where the nerve can be resected without compromising the motor supply to the extensor indicis or extensor pollicis longus. In addition, this study provides a guide to surgeons of the crucial anatomy on the dorsal aspect of the wrist during surgery to avoid injuring the last motor branch of the PIN and prevent unwanted complications.

The findings presented here are in agreement with Berger[1] and Fukumoto et al,[4] who described the consistency of the PIN location in the fourth extensor compartment of the wrist. They also confirmed that the last motor branch supplies the extensor indicis in the majority of cases. Elgafy et al stated that "In contrast to the study conducted by Reissis et al, the current study showed that the last muscular branch from the

Table 1 Various parameters measured in the study in relation to the posterior interosseous nerve

Parameters	Number of forearms studied	Mean	SD	Range
Diameter of PIN at most proximal part of ulnar head (mm)	30	0.5	0.1	0.4–0.7
Distance between the last motor branch of the PIN to most proximal part of ulnar head (mm)	30	46.9	8.4	33.4–65.2
Sagittal (anterior-posterior) distance between PIN and AIN at most proximal part of ulnar head (mm)	30	2.8	0.2	2.0–3.2

lateral subbranch was to the extensor pollicis longus rather than the extensor indicis, which was supplied by a branch from the medial subbranch."[6,7]

The PIN has been investigated for use as a nerve graft by Reissis et al.[8] The mean distance (~50 mm) between the DRUJ and the last motor branch of the PIN observed in this study confirm the approximate length of the PIN available for harvesting for nerve grafting. Waters and Schwartz reported that the range of the obtainable length of the nerve was 5 to 10 cm.[10] Elgafy et al showed that the mean obtainable length for harvesting the lateral subbranch of the fifth branch of the posterior interosseous nerve was 6.2 ± 0.7 mm.[6,7] Grafe et al performed a study on 10 cadavers.[5] The proximal ulnar head was selected as a readily palpable landmark for use as the reference point for measuring the branching points of the AIN. A dorsal forearm approach was performed and the interosseous membrane was divided. The average PIN diameter was 0.87 mm (range, 0.47–1.21 mm). The PIN was radial to the posterior interosseous artery in 5 of 10 specimens. The AIN consistently was found volar and ulnar to the PIN in 10 of 10 specimens. The AIN was radial to the anterior interosseous artery in eight specimens. The average AIN diameter was 1.5 mm (range, 1.1– 2.0 mm) before the first PQ motor branch. The average number of AIN motor branches was 4.2 (range, 2–7). This information enables surgeons to consider the terminal part of the PIN as an alternative for small nerve grafts.

Our study is similar to the study by Elgafy et al, who showed that in all the dissected specimens there was only a single branch that terminated at the wrist capsule: the lateral subbranch of the fifth branch of the PIN.[6] However, Waters and Schwartz reported that 18 of 26 PINs had a single terminal branch and the other eight had two or more terminal branches into the dorsal wrist capsule. The eight specimens with two or more major branches had a bulbous dilation proximal to the wrist capsule.[10] In contrast to those results, our study noted 11 out of 30 specimens to have the bulbous dilation proximal to the wrist capsule. We feel that these anatomical variations are important for surgeons to be aware of, to avoid incomplete denervations by missing the other branches. We also think that the bulbous enlargement of the terminal branch of the PIN may be a helpful guide to locate the PIN in denervation or nerve graft surgeries in which the PIN cannot be located proximally due to deformity or scarring from previous surgeries.

The present study also investigated the relationship between the PIN and AIN, confirming their close association (►**Table 1**). Previous studies have not considered the spatial relationship of these two nerves.[1,9] After giving its last motor branch, the PIN continues distally along the dorsum of the interosseous membrane supplying the wrist joint. Similarly, the AIN runs close to volar aspect of the interosseous membrane. We also showed that the AIN lies consistently ulnar to the anterior interosseous artery. Once the surgeon has located the PIN in the fourth dorsal wrist compartment, they can incise the interosseous membrane to locate the anterior interosseous artery and find the AIN lying ulnar to it. This information will enable surgeons to locate these nerves when performing regional blocks, help in planning minimal access wrist procedures such as Berger's partial wrist denervation, and develop endoscopic techniques for selective denervation. In addition, the close and consistent relationship of the PIN and AIN just proximal to the ulnar head supports the use of a single dorsal incision to access both the PIN and the AIN, as demonstrated in this study.

This current study suffers from the inherent limitation of any cadaveric study; that is, the findings cannot be used to infer definite measurements for the PIN in the clinical setting for either denervation or nerve graft surgery, and these values are at best approximate. In addition, we acknowledge that a source of error is that accurate X-ray localization of the proximal ulnar head with a radiopaque marker (such as an 18-gauge needle) was not performed before dissection, and this omission may have led to some discrepancies.

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Conflict of Interest

None

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